INTERFERENCE

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INTERFERENCE

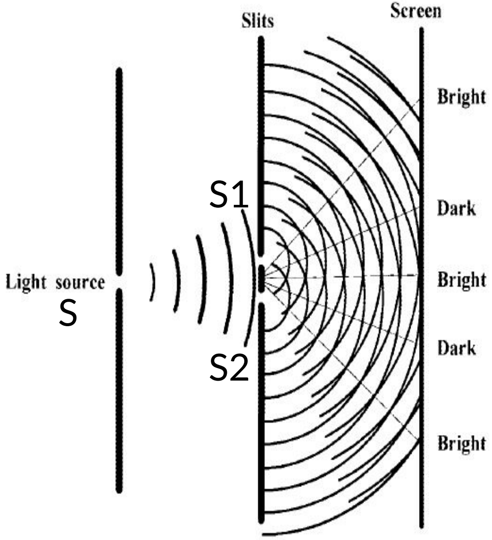
- When a single source of light is present in a medium then the energy distribution is uniform .
- If there are two adjacent exactly similar (coherent) sources, then the distribution of energy is no longer uniform. At some places energy is maximum and at other places it is minimum.
- This modification in the distribution of intensity in the region of superposition of two or more waves is called **Interference** .

The Phenomenon of Interference was first demonstrated by Thomas Young.

Sunlight was allowed to pass through a pinhole S. The light from S falls on another two pin holes S1 and S2 which are very close to each other and are equidistant from S.

Light waves spreading out from S1 and S2 interfere with one another, alternate bright and dark bands are produced on the screen as shown in the figure . They are known as interference fringes or Interference Bands

Explanation on the basis of wave theory : S1 & S2 are two sources of light. Light waves are transverse waves . Each wave is characterized by alternate crests and troughs .



When the crest of one wave falls on the crestof another or trough of one wave falls on the trough of another, they mutually reinforce each other and the amplitude increases. Hence intensity which is proportional to square of the amplitude is maximum. So maximum brightness is produced. This is known as **Constructive Interference** .

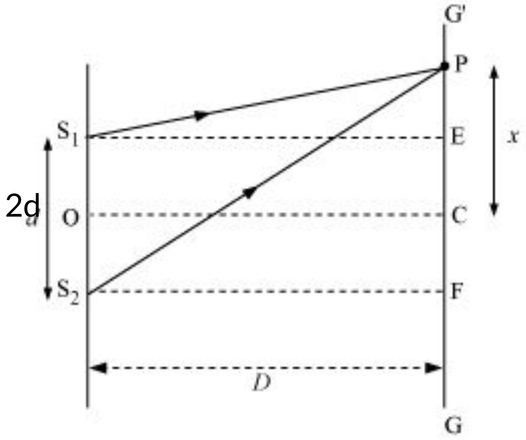
If the crest of one wave falls on the trough of another or the trough of one wave falls on the crest of another , they mutually destroy each other. So minimum brightness is produced. This is known as **Destructive Interference**.

These two together is known as **Interference**.

The distance between any two consecutive bright or dark Fringes is known as fringe width.

Theory of Interference Fringes

- S_1 and S_2 are two coherent sources separated at a distance 2d.
- A screen is placed at a distance D from the sources.
- The point C on the screen is equidistant from S_1 and S_2
- Therefore the path difference between the waves coming from S_1 and S_2 is Zero.
- Thus the point C has maximum intensity.
- Consider a point P at a distance x from C.
- The waves reaching the point P from S_1 and S_2 are as shown in the figure.
- The path difference between the waves coming from S1 and S2 is (S_2P-S_1P).



Path Difference

$$Path\,Difference = S_2P - S_1P = \frac{x(2d)}{D}$$

$$Phase\,Difference = \frac{2\Pi}{\lambda}(path\,difference)$$

$$\delta = \frac{2\Pi}{\lambda}(S_2P - S_1P)$$

$$\delta = \frac{2\Pi}{\lambda}\left(\frac{x(2d)}{D}\right)$$

Condition for Bright Fringe:

The point P is bright when the path difference is equal to integral multiples of λ

$$\frac{x_{n(2d)}}{D} = n\lambda$$

Where n=0,1,2,3 ...

$$x_n = \frac{n\lambda D}{2d}$$

The distance between any two consecutive bright fringes =

$$x_2 - x_1 = \frac{2\lambda D}{2d} - \frac{\lambda D}{2d} = \frac{\lambda D}{2d}$$ ----- (1)

Condition for Dark Fringe:

A point P is dark if the path difference is odd multiple of half wave length .

$$\frac{x_n(2d)}{D} = (2n+1)\frac{\lambda}{2} \quad where\, n = 0, 1, 2\ldots\ldots$$

$$x_n = \left(\frac{2n+1}{2}\right)\frac{\lambda D}{2d}$$

The distance between two consecutive dark fringes =

$$x_2 - x_1 = \frac{5\lambda D}{2(2d)} - \frac{3\lambda D}{2(2d)} = \frac{\lambda D}{2d}$$ -------(2)

Fringe Width(β)

The distance between any two consecutive bright or dark fringes is known as fringe width or band width (**β**)

From (1) and (2)

$$\beta = \frac{\lambda D}{2d}$$

$\beta \propto \lambda, \beta \propto$ D and $\beta \propto$ 1/2d

CONDITIONS FOR INTERFERENCE

I. <u>Condition for Sustained Interference</u> :

a) Two sources should be coherent i.e they should vibrate in the same phase or there should be a constant phase difference between them.

b)The sources must emit continuous waves of same wavelength and time period.

II. <u>Condition for good observation</u> :

a) The separation between the two sources (2d) should be small.

b) The distance between the sources and the screen should be large.

c) The background should be dark .

III. <u>Condition for good contrast</u> :

a) The amplitudes of interfering waves should be equal or nearly equal.

b) The two sources should be narrow.

c) The two sources should be monochromatic Sources.

TYPES OF INTERFERENCE

The interference is divided into two classes

a) Division of Wavefront b) Division of Amplitude

1. **Division of Wavefront** : The incident wavefront is divided into two parts by utilising the phenomenon of Reflection or Refraction . These two parts of the same wavefront travel unequal distances and reunite at some angle to produce interference bands.
   Ex : Fresnel's Biprism , Lloyds mirror belongs to this class.

2. **Division of Amplitude** : The amplitude of incoming beam is divided into two parts either by parallel Reflection or Refraction .
   Ex : Newton's Rings , Michelson's Interferometer etc..